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Abstract

- The U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) are planning to support the scale up of an enzyme hydrolysis based process for converting biomass to fuels
- DOE and NREL are using a stage-gate process to focus early stage, high risk research and help insure industry will move the technology to a demonstration scale and then to commercialization
- As the development effort proceeds toward commercialization, technical direction and funding will increasingly be undertaken by industrial partners
- The DOE is currently soliciting letters of interest from firms that would like to participate in the design, construction, and operation of the planned demonstration facility

Background

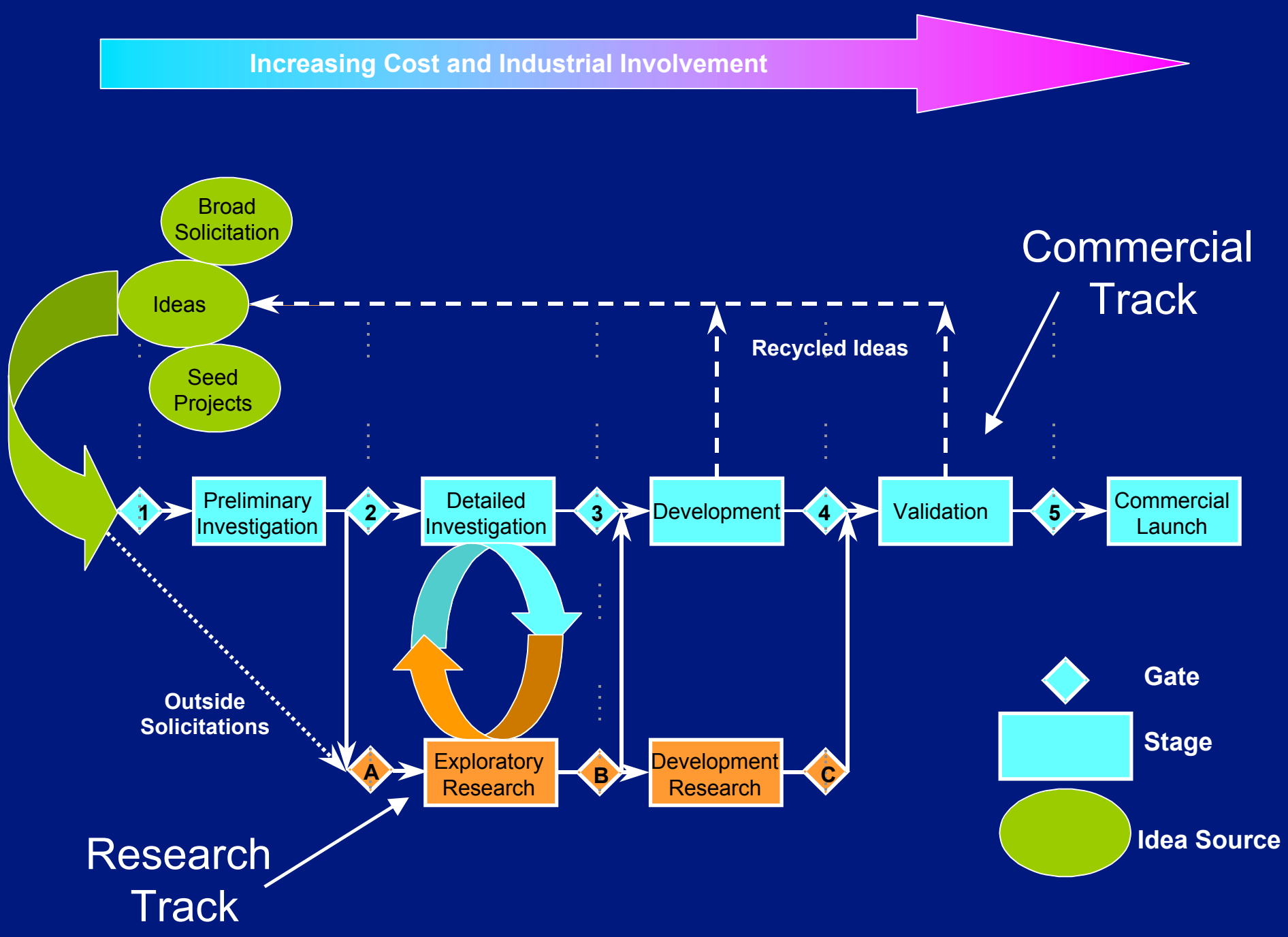
- The Department of Energy's Office of Fuels Development (DOE/ OFD) has been supporting research at NREL to cost-effectively convert biomass, including agricultural residues, to transportation fuels (i.e., bioethanol) and high-value co-products
- Current plans are to scale up an enzyme hydrolysis based process to a demonstration facility with industry partners
- Three factors are key to determining the cost of ethanol produced from biomass
  - Cost of delivered feedstock
  - Cost of enzymes used to make cellulose accessible to conversion to sugars
  - Capital cost of processing facilities

Key to market success will be to reduce the cost of bioethanol to that of competitive fuels and increase the value of co-products (sugars, lignin-based products, etc.)

The Stage-Gate Process

- The process was originally proposed as a model for ***product development*** projects to reduce costs and time to market
- Adapted and extended to basic research by process technology firms like Exxon, Rohm and Haas, and Eastman Chemical
- Modified by USDOE Biofuels Program for early stage, high risk ***Government-funded technology R&D*** to insure alignment with industry needs for later stage development and commercialization

Stage Gate Process

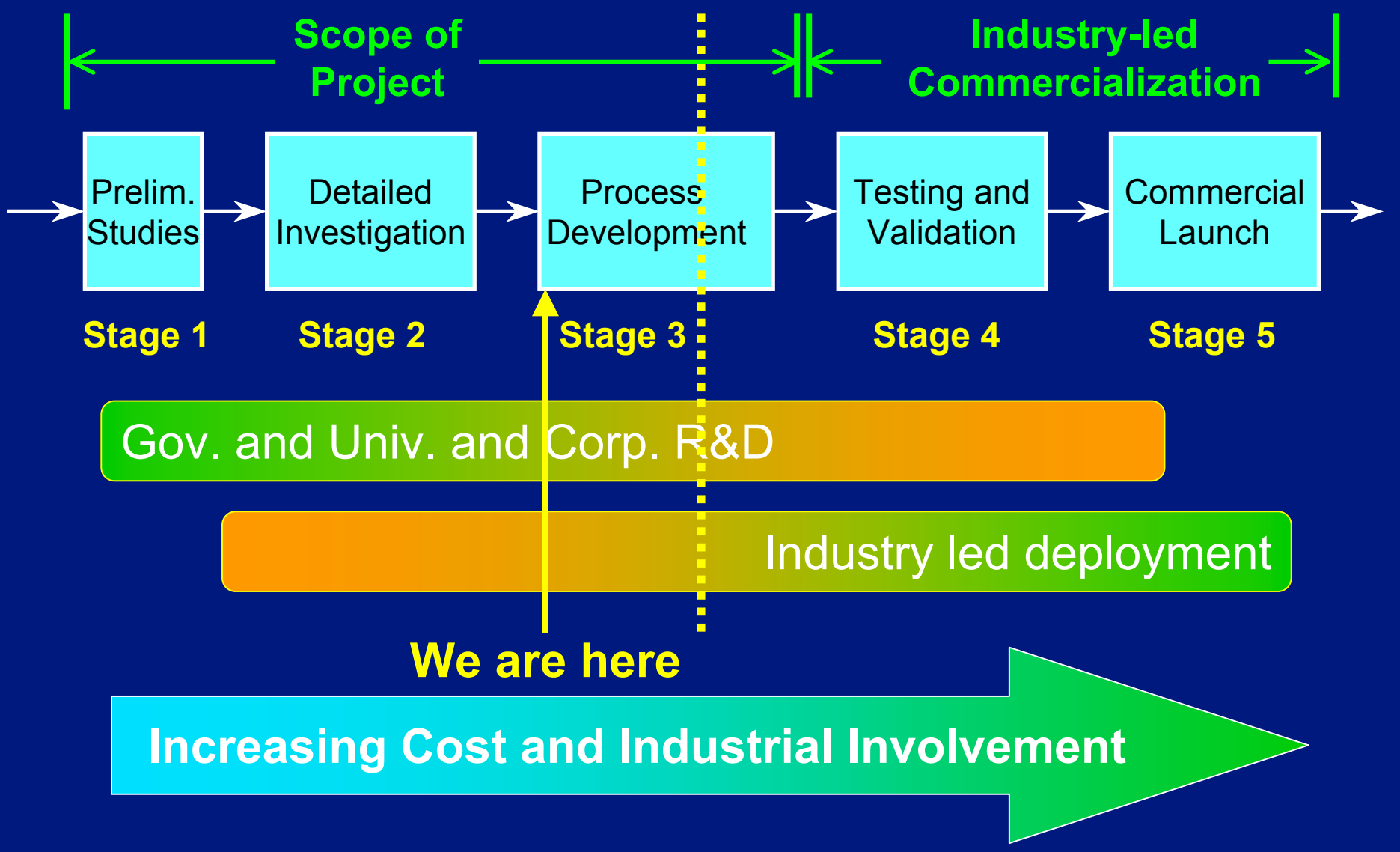


What the DOE/NREL Stage Gate Process Insures

- Strong Customer/Competition orientation
- Better homework up-front
- Quality of execution
- Sharper focus, better prioritization
- Fast-paced, parallel processing
- Multifunctional team approach

"Business Driven Science"

Enzyme Hydrolysis Project Stages



Recent Developments

- Major contracts awarded to Novozymes Biotech and Genencor International to reduce costs of cellulase enzymes by 10X by 2004
- Meetings held (November 2001) with potential industrial partners to discuss research progress, forms of cooperation, etc.
- External industrial reviewers determined (Jan. 2002) that the NREL Enzyme Sugar Platform Project was ready to pass into Stage 3 with a focus on core technologies and integrated testing
- NREL FY2002-2003 research focused on optimizing feedstock pretreatment, strain selection and adaptation, and process modeling
- In FY 2004-2005, NREL will complete integrated process development (including new low-cost enzymes) and expects to identify one or more teams of industrial partners

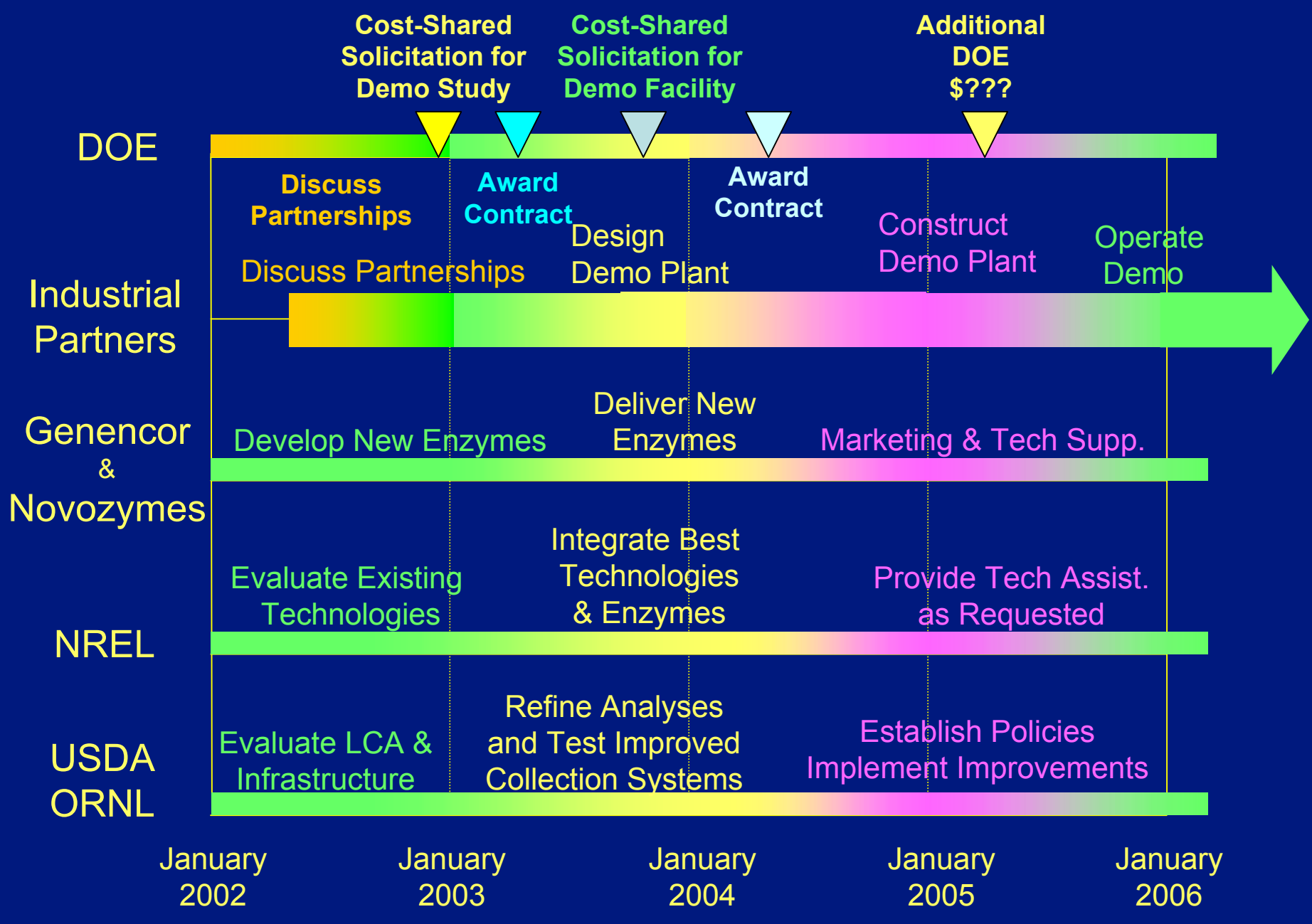
The Role of Industrial Partners

- Stage 3 (Process Development)
  - Develop new low-cost cellulases
  - Advise on feedstock collection and handling
  - Advise on pre-treatment approaches
  - Assist with process integration studies
  - Advise on needed information and scale for demonstration plant
- Stage 4 (Testing and Validation)
  - Select feedstock and output product slate
  - Conceptual and detailed design for cost-shared demonstration plant
  - Determine site for demonstration facility
  - Construct and operate demonstration facility
- Stage 5
  - Enlist commercial partners and line up plant construction financing
  - Design and construction of first commercial plants
  - Operate commercial-scale plant(s)
  - Modify initial designs to increase efficiency and profitability

The Implementation Schedule

- DOE plans to invite cost-shared industrial participation in the demonstration plant study, including design, in late FY 2002, with a contract award in mid FY 2003
- The detailed plant design would form the basis for a cost-shared solicitation for the demo plant construction in early FY 2004, with plant operation to begin in late FY 2005 or early FY 2006

Major Timeline Elements by Participant



DOE Solicitation for Letters of Interest from Potential Partners

- DOE is seeking early feedback and guidance from potential industrial partners on the plans for an enzymatic hydrolysis demonstration plant
- Industry input sought on key issues
  - Required scale to reduce commercialization risk
  - Feedstock
  - Slate of end products
  - Government cost-share required
- DOE Golden Field office has requested letters of interest in demo plant from interested firms or groups of firms
- Request posted on DOE/Golden web site: *http:www.golden.doe.gov/business%20opportunities/solicitations.html*
- Industry responses due by May 1, 2002